CLAIMS

What is claimed is:

1. A method for laying out an opaque field, alternating phase shift mask pattern and a trim mask pattern for use with the phase shift mask pattern to produce a target feature, the phase shift mask pattern including a first phase shift window having a first side and a second side opposite the first side and spaced away from the first side by a first phase shift window width, a second phase shift window with complementary phase, having a first side and a second side opposite the first side and spaced away from the first side by a second phase shift window width, an opaque field overlying a region of phase transition along the respective first sides in between the first and second phase shift windows, the opaque field having a control width, the trim mask pattern including an opaque trim shape in location corresponding with said region of phase transition and having a trim width in the dimension parallel with said control width; the method comprising:

applying an adjustment to at least one of the phase shift mask pattern and a trim mask pattern based upon one or both of a rule based correction and a model based correction to improve a match between a resulting exposure pattern and said target feature, said adjustment including more than one of:

(1) adjusting said first phase shift window width and said second phase shift window width,

(2) adjusting said control width,

(3) adjusting said trim width,

(4) adding a sub-resolution opaque shape to one or both of the first and second phase shift windows,

(5) adding a clear shape to the trim shape, and

(6) adding one or more opaque shapes to one or both of the first and second phase shift windows and adding a clear shape or shapes to the trim.

2. The method of claim 1, wherein said adjustment includes adding one or more opaque shapes to one or both of the first and second phase shift windows and adding a clear shape or shapes to the trim, and the one or more opaque shapes in the phase shift windows are at or above resolution, and

clear shape or shapes in the trim shape are below resolution.

3. The method of claim 1, wherein said adjustment includes adding one or more opaque shapes to one or both of the first and second phase shift windows and adding a clear shape or shapes to the trim, and the one or more opaque shapes in the phase shift windows are at or above resolution, and clear shape or shapes in the trim shape are at or above resolution.

4. The method of claim 1, wherein said adjustment includes adding one or more opaque shapes to one or both of the first and second phase shift windows and adding a clear shape or shapes to the trim, and the opaque shapes in the phase shift windows are at or above resolution, and clear shape or shapes in the trim shape are below resolution.

5. The method of claim 1, wherein said adjustment includes adding one or more opaque shapes to one or both of the first and second phase shift windows and adding a clear shape or shapes to the trim, and the opaque shapes in the phase shift windows are at or above resolution, and clear shape or shapes in the trim shape are at or above resolution.

6. The method of claim 1, wherein said adjustment includes adding a sub-resolution opaque feature to one or both of the first and second phase shift windows, and includes adding said sub-resolution opaque feature inside one or both of the first and second phase shift windows, wherein the first and second phase shift windows have respective perimeters, and said sub-resolution opaque feature is inside one or both of the first and second phase shift windows and does not contact said perimeters.

7. The method of claim 1, wherein said adjustment includes adding a sub-resolution opaque feature to one or both of the first and second phase shift windows, and said sub-resolution opaque feature includes an adjustment to at least one of the first and second phase shift windows, wherein said adjustment divides the at least one of the first and second phase shift windows into two or more phase shift windows, and does not touch said first side.

8. The method of claim 1, wherein said adjustment includes adding a clear feature to the trim shape, and said clear feature includes a clear field within said trim shape and parallel with said control shape.

9. The method of claim 1, wherein said adjustment includes adding a clear feature to the opaque trim shape, and said clear feature includes first and second clear fields within said opaque trim shape, said first and second clear fields being parallel with said control shape and having respective widths, and being spaced apart by a trim spacing.

10. The method of claim 1, wherein said adjustment includes adding a clear feature to the opaque trim shape, and said feature includes first and second clear fields within said opaque trim shape, said first and second clear fields being parallel with said control shape, and being symmetrically arranged with a common trim width, and being spaced apart by a trim spacing.

11. The method of claim 1, wherein said trim mask pattern is one of a binary mask pattern, and attenuated phase shifting mask pattern and a combination of a binary mask pattern and an attenuated phase shifting mask pattern.

12. A method for laying out an opaque field, alternating phase shift mask pattern and a trim mask pattern for use with the phase shift mask pattern to produce a target feature, the phase shift mask pattern including a first phase shift window having a first side and a second side opposite the first side and spaced away from the first side by a first phase shift window width, a second phase shift window with complementary phase, having a first side and a second side opposite the first side and spaced away from the first side by a second phase shift window width, an opaque field overlying a region of phase transition along the respective first sides in between the first and second phase shift windows, the opaque field having a control width, the trim mask pattern including an opaque trim shape in location corresponding with said region of phase transition and having a trim width in the dimension parallel with said control width; the method comprising:

applying an adjustment to at least one of the phase shift mask pattern and a trim mask pattern based upon one or both of a rule based correction and a model based correction to improve a

match between a resulting exposure pattern and said target feature, said adjustment including:

adding a clear feature to the trim shape.

13. The method of claim 12, wherein said clear feature includes a clear field within said trim shape and parallel with said control shape.

14. The method of claim 12, wherein said clear feature includes first and second clear fields within said opaque trim shape, said first and second clear fields being parallel with said control shape and having respective widths, and being spaced apart by a trim spacing.

15. The method of claim 12, wherein said clear feature includes first and second clear fields within said opaque trim shape, said first and second clear fields being parallel with said control shape, and being symmetrically arranged with a common trim width, and being spaced apart by a trim spacing.

16. The method of claim 12, wherein said adjustment further includes one or more of:

(1) adjusting said first phase shift window width and said second phase shift window width,

(2) adjusting said control width,

(3) adjusting said trim width.

17. The method of claim 12, wherein said adjustment includes adding a sub-resolution opaque feature to one or both of the first and second phase shift windows.

18. A method for laying out an opaque field, alternating phase shift mask pattern and a trim mask pattern for use with the phase shift mask pattern to produce a target feature, the phase shift mask pattern including a first phase shift window having a first side and a second side opposite the first side and spaced away from the first side by a first phase shift window width, a second phase shift window with complementary phase, having a first side and a second side opposite the first side and spaced away from the first side by a second phase shift window width, an opaque field

overlying a region of phase transition along the respective first sides in between the first and second phase shift windows, the opaque field having a control width, the trim mask pattern including an opaque trim shape in location corresponding with said region of phase transition and having a trim width in the dimension parallel with said control width; the method comprising:

applying an adjustment to at least one of the phase shift mask pattern and a trim mask pattern based upon one or both of a rule based correction and a model based correction to improve a match between a resulting exposure pattern and said target feature, said adjustment including:

adding one or more opaque shapes to one or both of the first and second phase shift windows and adding a clear shape or shapes to the trim shape.

19. The method of claim 18, wherein said adjustment includes adding one or more opaque shapes to one or both of the first and second phase shift windows and adding a clear shape or shapes to the trim, and the opaque shapes in the phase shift windows are at or above resolution, and clear shape or shapes in the trim shape are below resolution.

20. The method of claim 18, wherein said adjustment includes adding one or more opaque shapes to one or both of the first and second phase shift windows and adding a clear shape or shapes to the trim, and the opaque shapes in the phase shift windows are at or above resolution, and clear shape or shapes in the trim shape are at or above resolution.

21. The method of claim 18, wherein said adjustment includes adding one or more opaque shapes to one or both of the first and second phase shift windows and adding a clear shape or shapes to the trim, and the opaque shapes in the phase shift windows are at or above resolution, and clear shapes in the trim shape are below resolution.

22. The method of claim 18, wherein said adjustment includes adding one or more opaque shapes to one or both of the first and second phase shift windows and adding a clear shape or shapes to the trim, and the opaque shapes in the phase shift windows are at or above resolution, and clear shapes in the trim shape are at or above resolution.

23. The method of claim 18, wherein said adjustment includes adding a sub-resolution opaque feature to one or both of the first and second phase shift windows, and said adjustment further includes one or more of:

(1) adjusting said first phase shift window width and said second phase shift window width,

(2) adjusting said control width, and

(3) adjusting said trim width.

24. A method for producing a computer readable definition of a photolithographic mask pattern that defines a target pattern in a layer to be formed using the mask, wherein said target pattern includes a plurality of target features; the method comprising:

identifying cutting areas for phase shift regions based upon characteristics of said target pattern;

assigning phase values to phase shift windows in the phase shift regions;

wherein said assigning comprises cutting the phase shift regions in selected ones of the cutting areas to define cuts separating the phase shift regions into phase shift windows;

applying adjustments to the phase shift windows for proximity correction; and

storing a result of said laying out and said assigning in a computer readable medium.

25. The method of claim 24, wherein said identifying cutting areas includes:

identifying features in the plurality of features characterized by greater process latitude to define a set of features;

identifying fields between features in the plurality of features characterized by lesser process latitude to define a set of critical fields; and

defining cutting areas as areas within the phase shift regions which extend between two target features in the plurality of target features, or between a feature in a set of features and a field outside the phase shift regions, without intersecting a field in the set of critical fields.

26. The method of claim 25, wherein features characterized by lesser process latitude include features having critical dimensions.

27. The method of claim 24, including laying out a complementary mask including an opaque feature preventing exposure of a target feature of the target pattern formed by a phase transition in one of said cuts, the opaque feature including transmissive cut-outs over the cuts.

28. The method of claim 27, including adjusting said cut-outs using one of rule based and model based tools to improve matching between a resulting exposure and said target features.

29. The method of claim 24, wherein the computer readable definition includes definitions of an opaque field, alternating phase shift mask pattern and of a trim mask pattern for use with the phase shift mask pattern to produce a target feature, the phase shift mask pattern including a first phase shift window having a first side and a second side opposite the first side and spaced away from the first side by a first phase shift window width, a second phase shift window with complementary phase, having a first side and a second side opposite the first side and spaced away from the first side by a second phase shift window width, an opaque field overlying a region of phase transition along the respective first sides in between the first and second phase shift windows, the opaque field having a control width, the trim mask pattern including an opaque trim shape in location corresponding with said region of phase transition and having a trim width in the dimension parallel with said control width; and wherein said applying adjustments includes:

applying an adjustment to at least one of the phase shift mask pattern and a trim mask pattern based upon one or both of a rule based correction and a model based correction to improve a match between a resulting exposure pattern and said target feature, said adjustment including more than one of:

(1) adjusting said first phase shift window width and said second phase shift window width,

(2) adjusting said control width,

(3) adjusting said trim width,

(4) adding a sub-resolution opaque shape to one or both of the first and second phase shift windows,

(5) adding a clear shape to the trim shape, and

(6) adding one or more opaque shapes to one or both of the first and second phase shift windows and adding a clear shape or shapes to the trim.

30. A method of generating a phase shifted representation of a layer of an integrated circuit, the method comprising:

selecting a plurality of target features in a target layer representation of the integrated circuit for definition using a phase shift pattern;

defining a plurality of phase shift regions in the phase shift pattern for use in defining the plurality of structures;

identifying a plurality of cutting areas in the plurality of phase shift regions, the plurality of cutting areas indicating locations where a phase shift region in the plurality of phase shift regions can be divided into phase shift windows of complementary phase;

ranking the plurality of cutting areas;

identifying, and assigning phase values to, phase shift windows in the phase shift pattern by selectively using the plurality of cutting areas and the ranking to resolve phase conflicts;

applying adjustments to said phase shift representation based upon one or both of a rule based correction and a model based correction to improve a match between a resulting exposure pattern and said a corresponding one of the plurality of target features in the target layer representation; and

storing, in a machine readable medium, said phase shift representation of said layer including said phase shift windows and said adjustments.

31. The method of claim 30, wherein the phase shift representation includes definitions of an opaque field, alternating phase shift mask pattern and of a trim mask pattern for use with the phase shift mask pattern to produce a target feature, the phase shift mask pattern including a first phase shift window having a first side and a second side opposite the first side and spaced away from the first side by a first phase shift window width, a second phase shift window with complementary phase, having a first side and a second side opposite the first side and spaced away from the first side by a second phase shift window width, an opaque field overlying a region of phase transition along the respective first sides in between the first and second phase shift windows, the opaque field having a control width, the trim mask pattern including an opaque trim shape in location corresponding with said region of phase transition and having a trim width in the dimension parallel with said control width; and wherein said applying adjustments includes:

applying an adjustment to at least one of the phase shift mask pattern and a trim mask pattern based upon one or both of a rule based correction and a model based correction to improve a match between a resulting exposure pattern and said target feature, said adjustment including more than one of:

(1) adjusting said first phase shift window width and said second phase shift window width,

(2) adjusting said control width,

(3) adjusting said trim width,

(4) adding a sub-resolution opaque shape to one or both of the first and second phase shift windows,

(5) adding a clear shape to the trim shape, and

(6) adding one or more opaque shapes to one or both of the first and second phase shift windows and adding a clear shape or shapes to the trim.

32. The method of claim 30, wherein the ranking comprises treating each of the plurality of cutting areas as equally ranked.

33. The method of claim 30, wherein the plurality of cutting areas includes a first cutting area and a second cutting area, and wherein the first cutting area ranked as preferred over the second cutting area for selection during the assigning.

34. The method of claim 33, wherein the first cutting area comprises a cut to field and the second cutting area comprises a cut adjacent a contact landing pad.

35. The method of claim 30, wherein the assigning further comprises:

using each of the plurality of cutting areas to divide the plurality of phase shift regions into a plurality of phase shift windows;

assigning phase to each of the plurality of phase shift windows; and

selectively merging phase shift windows in the plurality of windows to reduce number of phase shift windows using the ranking.

36. The method of claim 30, wherein the assigning further comprises:

representing the plurality of phase shift regions and plurality of cutting areas using a graph data structure, the graph data structure representing the ranking and phase conflicts;

determining phase assignments using the graph data structure.

37. The method of claim 36, wherein the determining phase assignments further comprises identifying phase conflicts as cycles of odd length in the graph data structure.